CHAPTER 12
RIGGING ACCESSORIES

This chapter provides requirements for rigging accessories used in hoisting and rigging—shackles, eyebolts, rings, wire-rope clips, turnbuckles, rigging hooks, and load-indicating devices.

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12.1 GENERAL

a. The information presented in this chapter provides guidance for safely handling lifted loads. Diagrams are used to illustrate hoisting and rigging principles and good and bad rigging practices. This is not a rigging textbook; the information should be applied only by qualified riggers.

b. Rigging accessories that have been damaged or removed from service shall be made unusable for hoisting and rigging operations before being discarded.

c. Load tables are representative only and are not exact for all materials or all manufacturers.

d. Determine the weight of the load:

1. From markings on the load.

2. By weighing, if the load is still on the truck or railroad car.

3. From drawings or other documentation.

4. By calculation, using the load dimensions and the weights of common materials in Table 12-1.

e. Determine the center of gravity of the load as accurately as possible:

1. From drawings or other documentation.

2. From markings on the load.

3. By calculation.

f. Determine the best method to attach the load and select the lifting devices (e.g., eyebolts or shackles).

12.1.1 Inspections

a. The operator or other designated person shall visually inspect rigging accessories at the beginning of each work shift or prior to use for the following (records not required):

1. Wear.

2. Corrosion.

3. Cracks.

4. Nicks and gouges.

5. Distortion such as bending or twisting.

6. Evidence of heat damage from any cause.

b. A designated person shall determine whether conditions found during the inspection constitute a hazard and whether a more detailed inspection is required.

c. Rigging accessories having any of the following conditions shall be removed from service:

1. Cracks.

2. Distortion or deformation exceeding 15 percent of new conditions.

3. Any sign of incipient failure in shear for shackle pins.

4. Wear exceeding 10 percent of original dimensions.

5. Excessive corrosion.

6. Shackles not marked according to Section 12.3, “Shackles.”

7. Heat damage.

d. A designated person shall perform nondestructive examinations according to applicable ASTM standards when needed by the responsible line manager or that person's authorized representative.

e. A sample load test and inspection form is included as Exhibit I at the end of this chapter. This form is a sample only and is not intended to be mandatory.

Table 12-1. Weights of common materials.

Name of metal	Weight (lb/ft^3)	Name of material	Weight (lb/ft^3)
Aluminum	166	Bluestone	160
Antimony	418	Brick, pressed	150
Bismuth	613	Brick, common	125
Brass, cast	504	Cement, Portland (packed)	100–120
Brass, rolled	523	Cement, Portland (loose)	70–90
Copper, cast	550	Cement, slag (packed)	80–100
Copper, rolled	555	Cement, slag (loose)	55–75
Gold, 24-carat	1,204	Chalk	156
Iron, cast	450	Charcoal	15–34
Iron, wrought	480	Cinder concrete	110
Lead, commercial	712	Clay, ordinary	120–150
Mercury, 60 degrees F	846	Coal, hard, solid	93.5
Silver	655	Coal, hard, broken	54
Steel	490	Coal, soft, solid	84
Tin, cast	458	Coal, soft, broken	54
Uranium	1,163	Coke, loose	23–32
Zinc	437	Concrete or stone	140–155
		Earth, rammed	90–100
Name of wood		Granite	165–170
		Gravel	117–125
Ash	35	Lime, quick (ground loose)	53
Beech	37	Limestone	170
Birch	40	Marble	164
Cedar	22	Plaster of paris (cast)	80
Cherry	30	Sand	90–106
Chestnut	26	Sandstone	151
Cork	15	Shale	162
Cypress	27	Slate	160–180
Ebony	71	Terra-cotta	110
Elm	30	Traprock	170
Fir, Balsam	22	Water	65
Hemlock	31		
Maple, Oak	62		
Pine, Poplar	30		

12.1.2 Testing

a. Tackle assemblies, handling fixtures, and rigging accessories for critical-lift service shall have an initial proof-load test of 2 times the rated capacity. If proof-testing cannot be verified, the tackle shall be proof-tested before being used to make a critical lift.

b. Tackle assemblies, handling fixtures, and rigging accessories shall be tested as a unit when practical. When necessary, parts of such assemblies may be tested individually with the approval of the inspector.

c. Test loads shall be accurate to within -5 percent, +0 percent of stipulated values.

d. All parts showing damage or permanent deformation as a result of load-testing shall be replaced. Replacement parts shall be load-tested in accordance with this paragraph. Discarded parts shall be destroyed.

e. Multileg lift assemblies shall be load-tested based on any two legs sharing the entire load. Attach legs not undergoing test in a manner to ensure that load stability is not lost during the test.

f. Dynamometers and load cells shall be tested and calibrated at least once a year and when specified in the critical lift procedure before being used to make a critical lift. This also applies if they have not been used in the previous 6 months. All calibrated devices shall have a tag affixed indicating date of calibration, by whom they were calibrated, and the date that the next calibration is due.

12.1.3 Good and Bad Rigging Practices

Figure 12-1 illustrates some good and bad rigging practices.

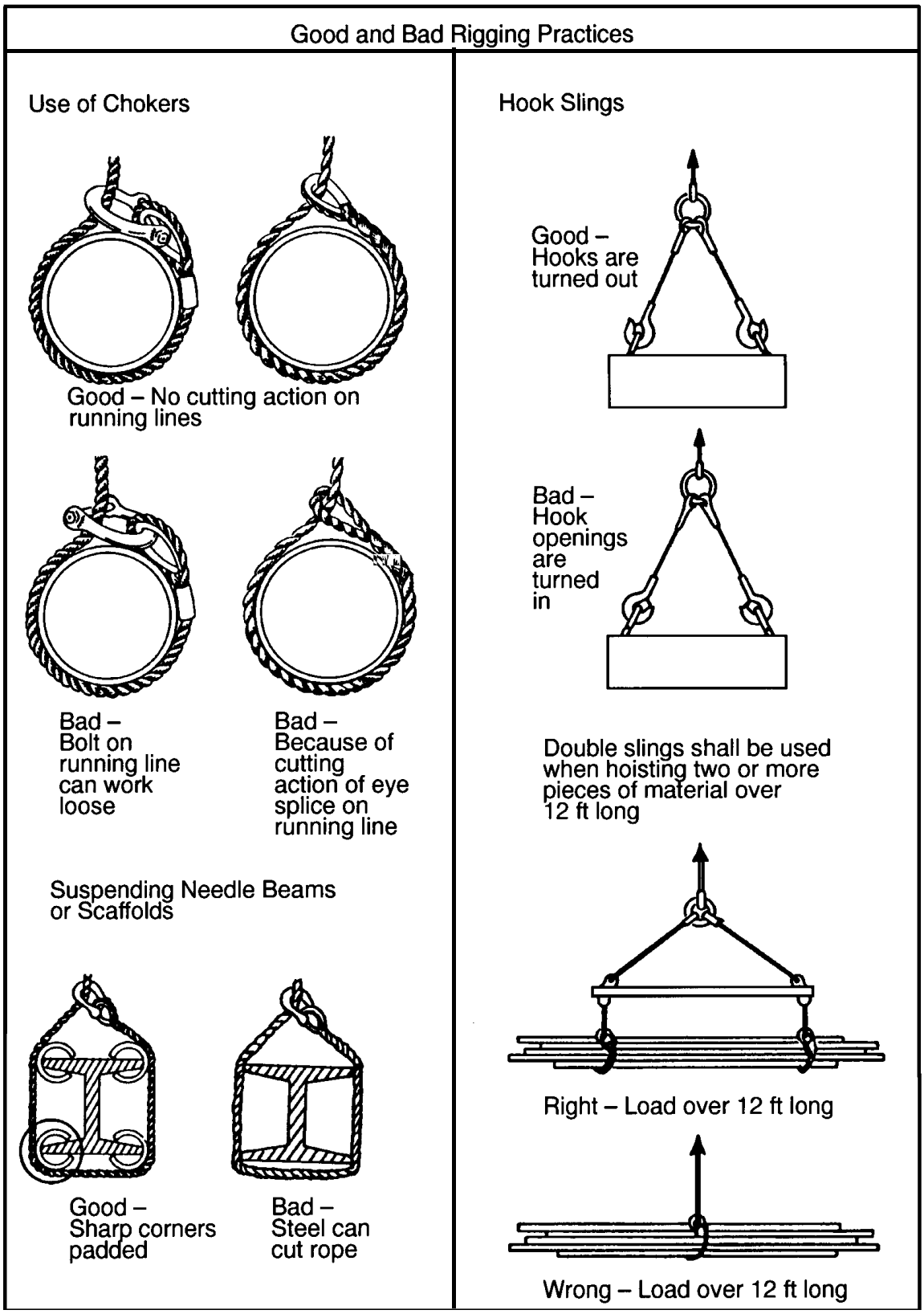
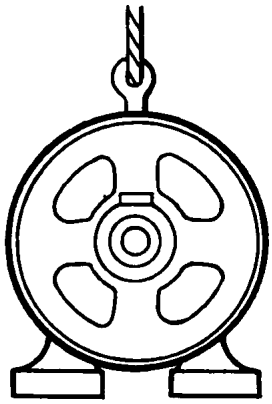


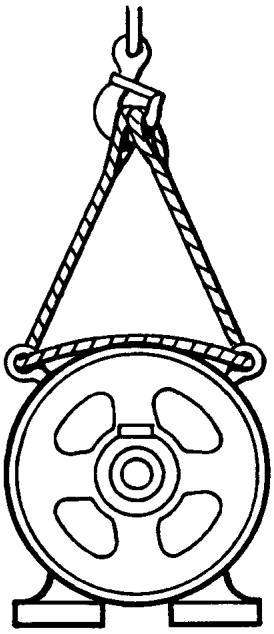
Figure 12-1. Good and bad rigging practices.

Good and Bad Rigging Practices

Eyebolts

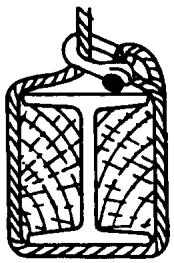


Good practice—vertical lift on eyebolt

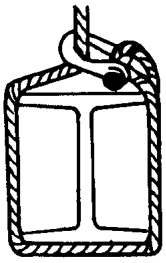


Bad practice – lifting on eye-bolts from an angle reduces safe loads as much as 90%

Hoisting Structural Steel



Good – Use space blocks and pad corners



Bad – Can bend flanges and cut rope

Eye Splices

Good practice – Note use of thimble in eye splice

Good practice – Use of thimble in eye splice

Bad practice – Wire rope knot with clip. Efficiency 50% or less

Bad practice – Thimble should be used to increase strength of eye and reduce wear on rope

Figure 12-1. (continued).

12.2 RIGGING HOOKS

12.2.1 Design

a. Hook design shall meet generally accepted hook design standards and be compatible with the requirements of ASME B30.10, Chapter 10-2, "Hook—Miscellaneous" (see Chapter 13, "Load Hooks," for equipment load hook requirements.)

b. Latch-equipped hooks shall be used unless the application makes the use of the latch impractical or unnecessary.

12.2.2 Marking

The manufacturer's identification shall be forged, cast, or die-stamped on a low-stress and nonwearing area of the hook.

12.2.3 Construction

a. The hook material shall have sufficient ductility to permanently deform before failure at the temperature at which the hook will be used.

b. Rated capacities for hooks shall equal or exceed the rated capacity of the chain, wire rope, or other suspension members to which they are attached.

12.2.4 Load Limits

A hook shall not be loaded beyond its rated capacity, except as is necessary to conform to the requirements for load testing of the sling or hardware to which it is attached. See Table 12-2 for hook capacity.

12.2.5 Inspections

12.2.5.1 Initial Inspection

a. A qualified inspector shall inspect all new and repaired hooks prior to initial use to ensure compliance with the applicable provisions of ASME B30.10 Section 10-2.2. Dated and signed inspection records shall be kept on file and shall be readily available.

b. Inspection procedure and record keeping requirements for hooks in regular service shall be determined by the kind of equipment in which they are used. When such requirements for hooks are stated in standards for the specific equipment, they shall take precedence over the requirements of this section.

12.2.5.2 Daily Inspection

a. The operator or other designated person shall visually inspect hooks daily or prior to first use, if the hook is not in regular service, for the following (records are not required):

1. Cracks, nicks, gouges.

2. Deformation.

3. Damage from chemicals.

4. Damage, engagement, or malfunction of latch (if provided).

5. Evidence of heat damage.

b. A designated person shall examine deficiencies and determine whether they constitute a safety hazard and whether a more detailed inspection is required.

12.2.5.3 Frequent Inspection

a. The operator or other designated personnel shall visually inspect the hook at the following intervals (records are not required):

1. Normal service—monthly.

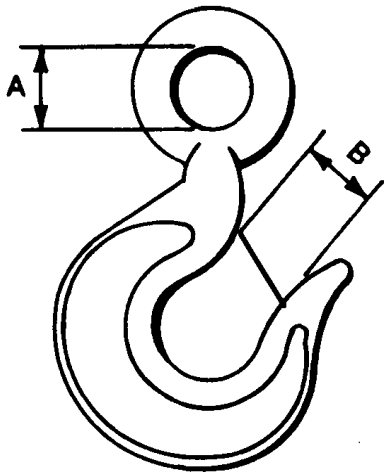
2. Heavy service—weekly to monthly.

3. Severe service—daily to weekly.

b. Hook service is defined as follows:

1. Normal service—operation at less than 85 percent of rated capacity except for isolated instances.

Table 12-2. Strength of standard sling hooks.



Standard hook number	Inside diameter of Eye A (in.)	Throat Opening B (in.)	Rated capacity (tons)
22	3/4	1	0.5
23	7/8	1 1/16	0.6
24	1	1 1/8	0.7
25	1 1/8	1 1/4	1.2
26	1 1/4	1 3/8	1.7
27	1 3/8	1 ½	2.1
28	1 ½	1 3/4	2.5
29	1 5/8	1 7/8	3.0
30	1 3/4	2 1/16	4.0
31	2	2 1/4	4.7
32	2 3/8	2 ½	5.5
33	2 3/4	3	6.8
34	3 1/8	3 3/8	8.0
34[a]	3 1/4	3 5/8	10.0
35	3 ½	4	11.0
36	4	4 ½	20.0
38	4 ½	5	30.0

Notes:

a. The above values are for “Vulcan” and similarly designed standard hooks.

b. The capacity can be found by the diameter of the hole in the eye of the hook. If the throat opening of any hook exceeds the dimension given above the corresponding diameter of the eye, the hook has been over strained and must not be used.

2. Heavy service—operation at 85 to 100 percent of rated capacity as a regular specified procedure.

3. Severe service—operation at heavy service coupled with abnormal operating conditions.

c. These inspections shall, in addition to the requirements of Section 12.2.5.2, "Daily Inspections," include the following:

1. Wear.

2. Hook attachment and securing means.

d. A designated person shall examine deficiencies and determine whether a more detailed inspection is required.

12.2.5.4 Periodic Inspection

a. A qualified inspector shall perform a complete inspection at the following intervals:

1. Normal service—yearly.

2. Heavy service—semiannually.

3. Severe service—quarterly.

b. A qualified inspector shall examine deficiencies and determine whether they constitute a safety hazard.

c. The inspection shall include the requirements of Section 12.2.5.3, "Frequent Inspection."

d. Hooks shall receive a nondestructive examination according to applicable ASTM standards annually.

e. Hooks having any of the following conditions shall be removed from service until repaired or replaced:

1. Deformation—Any bending or twisting exceeding 10 degrees (or as recommended by the manufacturer) from the plane of the unbent hook.

2. Throat opening—Any distortion causing an increase in throat opening exceeding 15 percent (or as recommended by the manufacturer).

3. Wear—Any wear exceeding 10 percent (or as recommended by the manufacturer) of the original section dimension of the hook or its load pin.

4. Cracks.

f. If a latch is provided and it becomes inoperative because of wear or deformation or fails to fully bridge the throat opening, the hook shall be removed from service until the device has been repaired or replaced and the throat opening has been determined not to exceed 15 percent (or as recommended by the manufacturer).

g. Dated and signed inspection records shall be kept on file and shall be readily available.

12.2.6 Testing

a. Hooks not attached to slings or other lifting hardware shall be proof tested to 200 percent of the rated capacity prior to initial use. The test load shall be accurate to within -5 percent, +0 percent of stipulated values.

b. No performance testing of hooks shall be required, except as is necessary to conform to the requirements for the slings or rigging hardware of which they are a part.

12.2.7 Maintenance

a. A designated person shall repair cracks, nicks, and gouges by grinding longitudinally, following the contour of the hook, provided that no dimension is reduced more than 10 percent of its original value (or as recommended by the manufacturer).

b. All other repairs shall be performed by the manufacturer.

12.2.8 Operation

The following shall apply to rigging hook users:

a. Determine that the load or force required does not exceed the rated capacity of the hook's assembly, especially when considering special conditions such as choking or grabbing.

b. Avoid shock loading.

c. Keep hands, fingers, and body from getting between the hook and the load.

12.3 SHACKLES

a. Shackles are made of drop-forged steel bent into shape. They are strong, closed attachments that will not come unhooked. The size is specified by the diameter of the body. Avoid side pulls on the shackle body.

b. Shackle pins should fit free without binding. Do not substitute a bolt for the shackle pin. Figure 12-2 shows shackles and provides examples of good and bad practices and inspection points.

c. Each shackle body shall be permanently and legibly marked by the manufacturer. Raised or stamped letters on the side of the bow shall be used to show:

1. Manufacturer's name or trademark.

2. Size.

3. Rated capacity.

d. Shackles that are not properly marked shall be permanently removed from service.

e. When shackles are used at load angles other than 90 degrees , the safe-load rating shall be reduced accordingly.

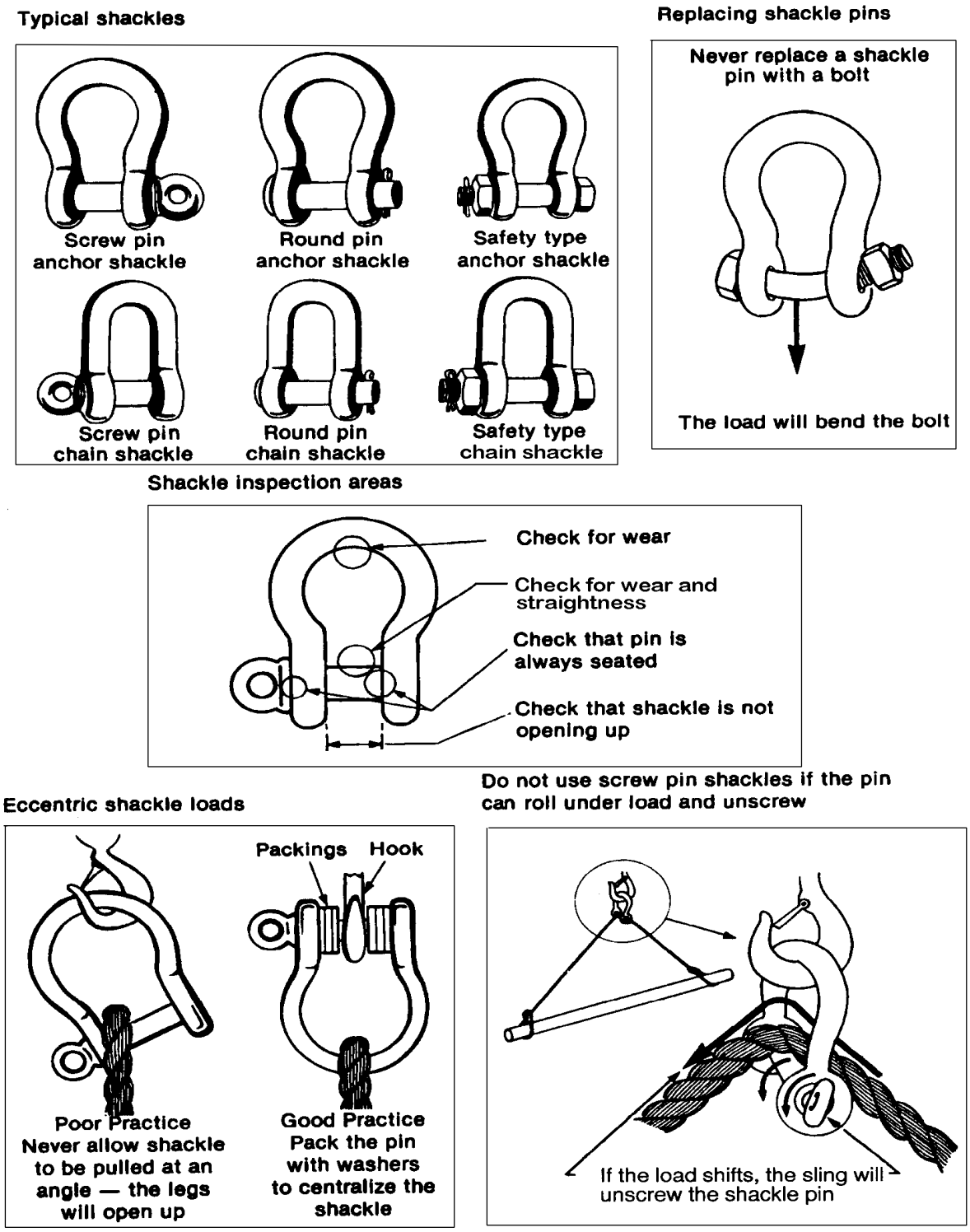


Figure 12-2. Shackles.

12.4 EYEBOLTS

a. This section specifies requirements for eyebolts that are used as rigging hardware during normal hoisting and rigging activities. Eyebolts designed for and permanently installed on existing engineered equipment are considered part of the engineered equipment, and they may not meet all requirements specified for rigging hardware. Eyebolts permanently installed on engineered equipment are acceptable for their intended use so long as they pass normal visual inspection before use. It is important to know how the manufacturer or engineered equipment intends permanently installed eyebolts to be used. In some cases the intended use is obvious to an experienced craftsman in other cases engineering review of vendor information may be necessary.

CAUTION: Eyebolts installed by the manufacturer to lift only parts of the engineered equipment are not suitable for lifting the completed piece of equipment. When questions arise regarding the use of manufactured-installed eyebolts, the equipment custodian or cognizant engineer shall be consulted.

b. Eyebolts used for hoisting shall be fabricated from forged carbon or alloy steel.

c. Eyeballed marking:

1. Carbon Steel Eyebolts shall have the manufacturer's name or identification marked forged in raised characters on the surface of the eyeballed.

2. Alloy Steel Eyebolts shall have the symbol "A" (denoting alloy steel) and the manufacturer's name or identification mark forged in raised characters on the surface of the eyebolt.

d. Eyebolts shall have a minimum design factor of 5:1.

e. Eyebolts shall have Class II fit and have a minimum of one-and-one-half diameters thread engagement. Nuts on through-eyebolts shall be self-locking or shall be secured with lock wires or other suitable means to prevent loosening.

f. The following shall apply to eyebolt users:

1. Use shouldered eyebolts for all applications, except where it is not possible due to the configuration of the item to be lifted. See Figure 12-3. When unshouldered eyebolts are used, do not use nuts, washers, and drilled plates to make shouldered eyebolts.

2. Do not use wire-type or welded eyebolts in DOE-lifting operations.

3. Ensure shoulders seat snugly against the surface on which they bear.

4. Spacers may be used, if necessary, to ensure proper seating of the eyebolt. Use a flat spacer no thicker than 1/16 of the outside diameter and approximately the same diameter as the maximum axis of the eyebolt shoulder with the smallest inside diameter that will fit the eyebolt shank.

5. Spot-face or slightly counterbore the surface of the item to which the eyebolt is fastened to the minimum depth needed for cleanup of the surface and complete bearing of the shoulder or spacer on the bearing surface.

6. Carefully inspect each eyebolt before use. Visually inspect the hole to ensure that there has been no deformation. Check the condition of the threads in the hole to ensure that the eyebolt will secure and the shoulder can be brought down snug. Destroy eyebolts that are cracked, bent, or have damaged threads.

7. Ensure that the shank of the eyebolt is not undercut and is smoothly radiused into the plane of the shoulder or the contour of the ring for nonshouldered eyebolts.

8. When more than one eyebolt is used in conjunction with multiple-leg rigging, spreader bars, lifting yokes, or lifting beams should be used to eliminate angular lifting. However, where spreaders, yokes, or beams cannot be used, eyebolts may be used for angular lifting, provided that the limiting conditions in Table 12-3 are considered. An angular lift is any lift in which the lifting force is applied at any angle to the centerline of the shank of the eyebolt.

9. Where nonshouldered eyebolts must be used for a critical lift, ensure that an engineering analysis of the loading and load vectors is made and approved before use. Minimize the angle between the sling and the eyebolt axis. In no case shall the eyebolt loading exceed the values shown in Table 12-3.

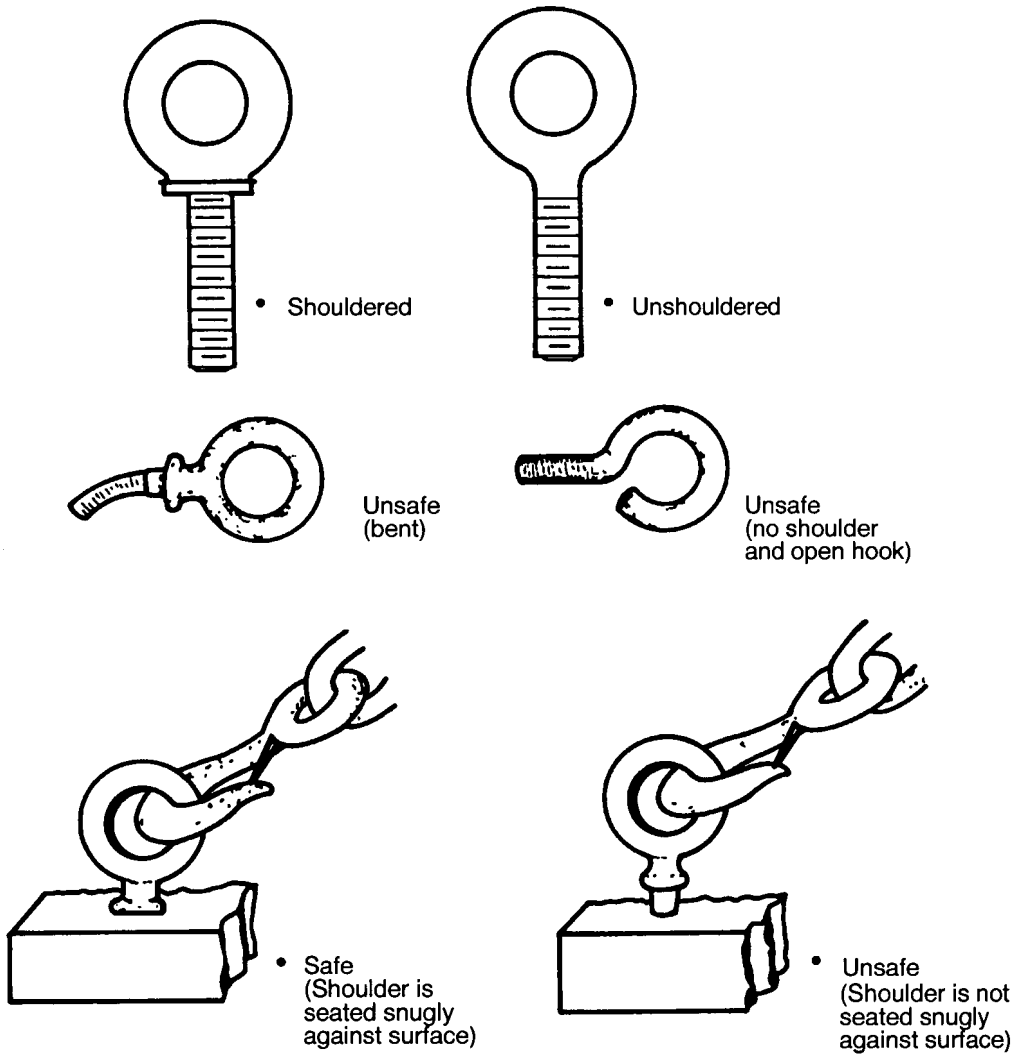
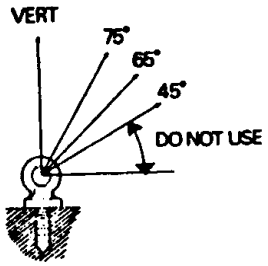


Figure 12-3. Eyebolts.

Table 12-3. Safe loading of eyebolts.

EYEBOLTS
— Shoulder Type Only
— Forged Carbon Steel



Stock diameter (in.)	SAFE WORKING LOADS CORRESPONDING TO ANGLE OF PULL				
	Vertical	75 degrees	60 degrees	45 degrees	Less than 45 degrees
1/4 5/16 3/8 ½ 5/8 3/4 7/8 1 1 1/4 1 ½	500 800 1,200 2.200 3,500 5,200 7,200 10,000 15,200 21,400	Reduce vertical loads by 45%	Reduce vertical loads by 65%	Reduce vertical loads by 75%	NOT RECOMMENDED

Note: The safe working loads for plain (shoulder less) eyebolts is the same as for shoulder bolts under vertical load. Angular loading is not recommended.

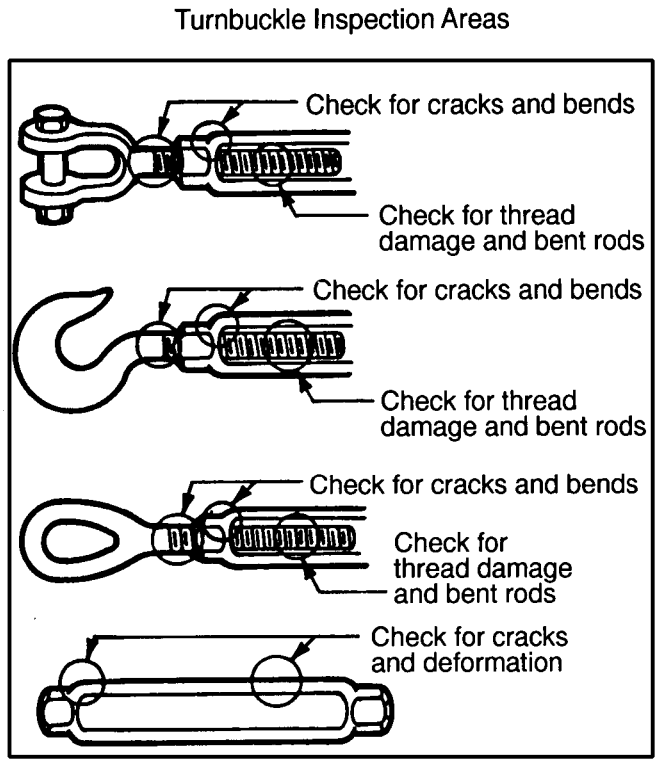
12.5 TURNBUCKLES

a. Turnbuckles may be used in sling systems provided that they are engineered, designed, and approved as a part of the sling system. Approved turnbuckles shall be marked and identified for use with the sling set for which they were designed and shall be load-tested as part of the sling set. Before each use, turnbuckles shall be inspected for damage. Damaged threads, jamb nuts, or bent frame members make the unit unsuitable for use.

b. Jamb nuts or locking devices must be tightened or locked before making lifts with turnbuckles. See Figure 12-4 for safe working load information and turnbuckle inspection areas.

c. Turnbuckles shall be fabricated from forged alloy steel and shall have a minimum design factor of 5:1.

d. Turnbuckles used in applications where there is vibration shall be secured to the frame with locks, pins, or wires to prevent turning or loosening.



Turnbuckles

- Weldless Construction
- Forged Alloy Steel

End fitting, stock diameter (in.)	Safe working load (SWL) of any combination of jaw end fittings, eye end fittings, and stub end fittings (lb)	SWL of any turnbuckle having a hook end fitting (lb)
1/4	500	400
5/16	800	700
3/8	1,200	1,000
1/2	2,200	1,500
5/8	3,500	2,250
3/4	5,200	3.000
7/8	7,200	4,000
1	10,000	5,000
1 1/4	15,200	5,000
1 1/2	21,400	7,500
1 3/4	28,000	—
3	37,000	—
2 1/2	60,000	—
2 3/4	75,000	—

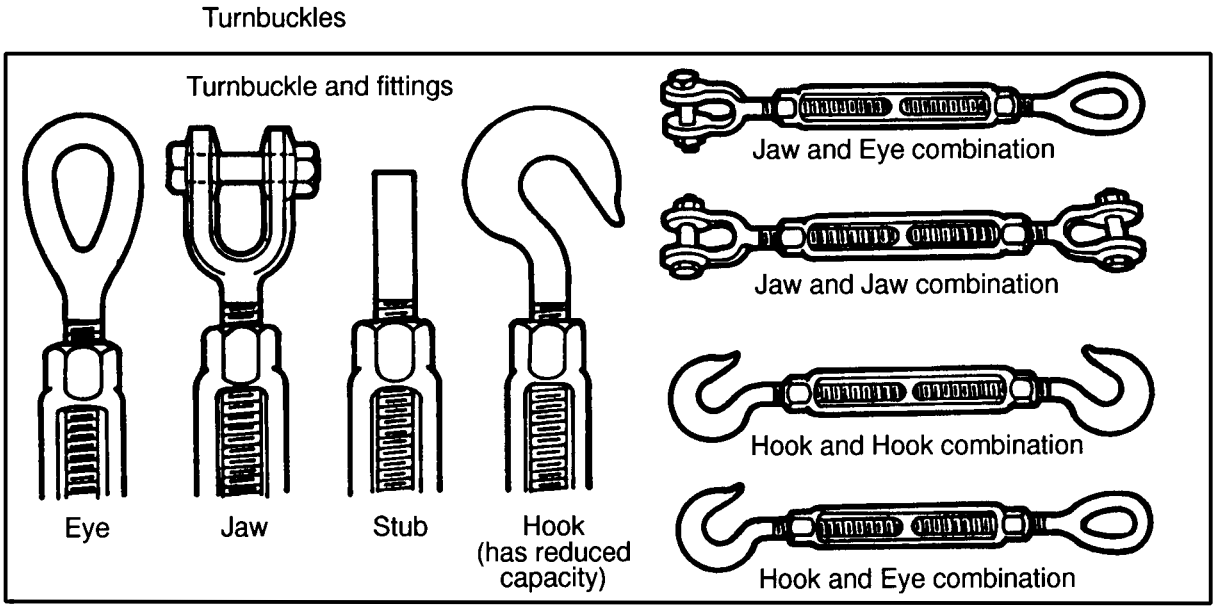


Figure 12-4. Turnbuckles.

12.6 LINKS AND RINGS

Links and rings are usually designed and manufactured as a part of the lifting hardware for a specific purpose, such as the peak link on multiple-leg slings. However, the rings and links may also be found on the load-attachment end of slings. Figure 12-5 shows typical rings and links. Table 12-4 provides safe loads for weldless rings and links.

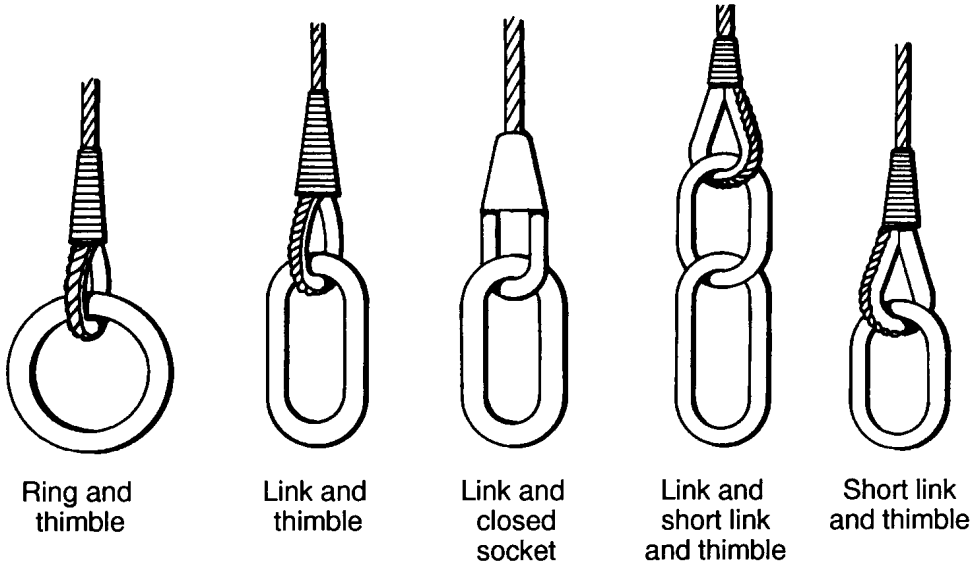


Figure 12-5. Rings and links.

Table 12-4. Safe loads for weldless rings and links.

RINGS

Dimensions Diam., stock (in.)	Diam., inside (in.)	Est. wt., each (lb)	Safe load, single pull (lb)
7/8	4	2 3/4	7,200
7/8	5 1/2	3 1/2	5,600
1	4	3 5/8	10,800
1 1/8	6	6 1/2	10,400
1 1/4	5	7	17,000
1 3/8	6	10	19,000

SLING LINKS

Diam., stock (in.)	Length, inside (in.)	Inside width, small end	Inside width, large end	Est. wt. per 100 (lb)	Safe load, single pull (lb)
3/8	2 1/2	3/8	1 1/4	23	1,800
1/2	3	1/2	1 5/8	50	3,200
*5/8	3 3/4	1 1/4	2 1/2	110	4,200
*3/4	4 1/2	1 1/2	3	190	6,000
*7/8	5 1/4	1 3/4	3 1/2	285	8,300
*1	6	2	4	430	10,800
1 1/4	6	1 1/4	3 3/4	700	22,000
*1 3/8	8 1/4	2 3/4	5 1/2	1125	20,500

*Sizes of sling links denoted by the asterisk are new and have the larger inside dimensions needed for 2-leg slings.

END LINKS

Diam., stock (in.)	Inside length (in.)	Inside width (in.)	Est. wt. per 100 (lb)	Suggested safe loads (lb)
5/16	1 3/4	1/2	14	2,500
3/8	1 7/8	9/16	21	3,800
1/2	2 3/8	3/4	48	6,500
5/8	3 1/4	1	92	9,300
3/4	3 1/2	1 1/8	137	14,000
7/8	5 1/8	2	275	12,000
1	5 1/8	2	360	17,000
1 1/4	6 7/16	2 1/4	700	28,000
1 3/8	7 3/4	2 3/4	1000	30,000

12.7 METAL-PLATE CLAMPS

a. Metal-plate clamps are designed specifically for lifting metal plates. They may also be used for lifting fiber sheets. Their grip or hold is determined by the weight or pull of the load.

b. The following applies to users of metal-plate clamps:

c. The plate shall be inserted all the way into the clamp to obtain a good grip. Ensure proper orientation of the clamp. See Figure 12-6.

d. Plate clamps are suitable for handling only one plate at a time.

e. Avoid side pulls on plate clamps.

f. Check plate clamps for wear in the jaws and for loose, worn, or broken parts.

g. Ensure that the rated capacity of each plate clamp is stamped on its body.

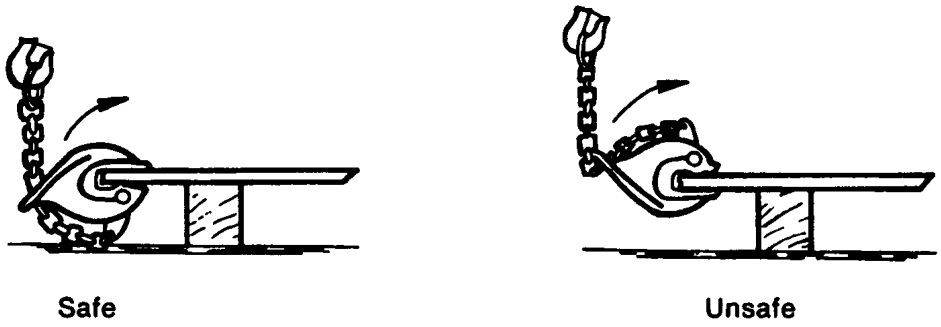


Figure 12-6. Metal-plate clamps.

12.8 LOAD-INDICATING DEVICES

a. Load-indicating devices are not required in routine operations where loads of known and essentially consistent weight are to be handled. Rather, load-indicating devices are required for use with loads of uncertain weight that could be within 90–100 percent of the rated capacity of the equipment or maximum working load of any part of the tackle. Use load-indicating devices where the equipment/ tackle configuration could result in binding or friction of the load that could cause a greater stress in the hoist or tackle than would result from the apparent hook load.

b. The accuracy of load-indicating devices shall depend on the requirements of the load system planned and shall not restrict the system requirements; an accuracy of 2 percent of full-scale reading within 10–70 percent of instrument range is recommended. The device should be selected so that the estimated hook load lies between 10 and 70 percent of the instrument range.

c. Dynamometers commonly have design factors of less than 5:1. Any combination where the safety factor of the dynamometer times the capacity of the dynamometer divided by the load equals 5 is acceptable.

d. When dynamometers are used as load-bearing parts of rigging, they must be constructed to provide a measure of safety and reliability equal to that of the associated rigging, or a safety device must be installed to prevent dropping the load in the event of a failure.

12.9 PRECISION LOAD POSITIONERS

a. A precision load positioning device in the load path shall have a design factor of no less than 5:1, based on ultimate strength of the device's load bearing components.

b. A precision load positioner shall be operated, maintained, calibrated and tested in accordance with the manufacturer's instructions.

c. Prior to initial use, all new, repaired, and altered precision load positioning devices shall be load tested, and a written report shall be furnished, confirming the load rating. If the load test is not performed by the manufacturer, it shall be done under the direction of a designated or authorized person in strict compliance with the manufacturer's instructions. Special attention should be paid to the manufacturer's instructions concerning testing of devices equipped with load gages as they may be damaged during the load test.

Exhibit I is intended to be a sample
form only and is not mandatory.
Any other form that accomplishes
the purpose is acceptable.

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EXHIBIT I

RIGGING, TACKLE, ACCESSORIES LOAD TEST AND INSPECTION
(HOOKS, SHACKLES, RINGS, ETC.)

INSPECTOR _____ INSPECTION DATE _____

NOTES:

1. Proof test to 200% of rated capacity for critical lift service to certify new equipment procured without manufacturer's certification. Test loads shall be accurate to within -5%, +0% of the stipulated values.

_____ 2. Qualified inspector shall witness all steps below.

_____ 3. Accept/reject data should be to manufacturer's specifications. Hooks, shackles, rings, and the like, shall be removed from service and discarded if any of the following conditions are present that would cause doubt of the integrity of the accessories:

   A. Corrosion, damage, or undue wear

   B. Cracks, twists, or significant change in openings

      (1) 15% more than normal opening

      (2) 10% twist more than normal from the plane of the unbent hook

      (3) 10% wear

      (4) 5% elongation of the hook shank.

   C. Heat damage.

_____ 4. Shackles, rings, etc.

   A. Wear, corrosion, spreading, and deformation

      (1) 15% deformation of their new condition

      (2) Shackle pins—any sign of incipient failure in shear.

Type _____ Size _____ Rated Capacity (SWL) _____

Tested to _____

Serial Numbers _____ _____ _____ _____ _____ _____

Qualified inspector shall perform a nondestructive test by visual examination, liquid penetrant examination, or magnetic particle examination.
Acceptance: No cracks, linear indications, laps, or seams.

QUALIFIED INSPECTOR VERIFY _____ DATE _____